IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	David C. Collins	Examiner:	Jeffrey S. Smith
Serial No.:	10/821,130	Group Art Unit:	2624
Filed:	April 8, 2004	Docket No.:	200400519-1
Title:	GENERATING AND DISPLAYING SPATIALLY OFFSET SUB-FRAMES		

DECLARATION OF PRIOR INVENTION UNDER 37 C.F.R. § 1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir/Madam:

This Declaration is submitted to establish prior invention of the subject matter of the present patent application. The person making this Declaration is inventor David C. Collins.

Accompanying this Declaration is Exhibit A to establish reduction to practice of the subject matter of the present patent application in the United States prior to the publication date of February 12, 2004 of U.S. Patent Application No. US 2004/0027363 (hereinafter referred to as "Allen").

Exhibit A (10 pages) includes a Hewlett-Packard Company (HP) Invention Disclosure and attachment submitted by the inventor and received by the HP Legal Department prior to February 12, 2004. In addition, this invention disclosure was witnessed prior to February 12, 2004. This invention disclosure was assigned HP Patent Disclosure No. 200400519. The invention disclosure and attachment describe the subject matter of the present patent application.

From this exhibit, it can be seen that the subject matter of the present patent application was reduced to practice prior to the publication date of February 12, 2004 of Allen.

As a person signing below, I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed: David C. Collins Date: 28-May-2008

David C. Collins

invent

200400519: A Practical Implementati...

Innovation Number
200400519

Disclosure Summary

Title A Practical Implementation of Multipass Adaptive Wobulation

Abstract Optimal subframe generation for wobulation can be implemented with an interative algorithm. This disclosure describes a practical method for implementing multiple passes of the wobulation subframe generation algorithm.

Attachments Adaptive_Kernel_With_History2.doc [188928 bytes] -

Inventors David C Collins

Invention Disclosures

invent

Disclosure No. 200400519

PD No.	Date/Time Submitted	Collection
200400519		

General Information

Title	A Practical Implementation of Multipass Adaptive Wobulation
Abstract	Optimal subframe generation for wobulation can be implemented with an interative algorithm. This disclosure describes a practical method for implementing multiple passes of the wobulation subframe generation algorithm.
Projects	
Products	

Attachments

Attachments	Adaptive_Kernel_With_History2.doc [188928 bytes] -

Description of Invention

Problems Solved	Optimal subframe generation for wobulation is computationally complex. Niranjan at HP Labs has previously disclosed an iterative method for solving the optimal subframe generation problem. This

	has been called the adaptive wobulation method. Running multiple iterations of the adaptive algorithm is expensive in terms of memory bandwidth, and is not practical for a consumer grade product. This disclosure describes a method for computing multiple passes of the adaptive algorithm with limited memory bandwidth requirements.
Prior Solutions	Two straight forward methods exist for optimal subframe generation using the adaptive method. The first method is to simply run the algorithm for multiple iterations. This results in the following steps: 1) Create the initial subframe 2) Generate a simulated image (i.e. merge the subframes together) 3) Calculate the error by subracting the simulated image from the original image 4) Feedback the error to update the subframes goto step 2 This method requires a great deal of memory bandwidth as the simulated image must be stored in memory, and the subframes must be stored in memory for each iteration. The second method is to apply the iterative algorithm on a portion of the image, and then calculate the final subframe value in a single step. Once a value have been calculated, the region of interest is shifted and a new value is calculated. This method requires a small amount of memory bandwidth, but many calculations are redundant, and the internal memory requirements of the calculation hardware are still quite large. The region of interest grows as the number of interations grows. Thus, to date, only one pass of the adaptive algorithm has been seriously proposed.
Description	The description is given in the attached document. In summary, the invention reduces the number of rows of data that are required for the multipass adaptive wobulation algorithm. This is accomplished by making a small compromise for some of the initial values, and by keeping track of the previous row of final subframe values.
Advantages	This invention enables multipass wobulation to be implemented in an ASIC without increasing the memory bandwith requirements. Also, the amount of on chip memory is kept relatively small. The techniques in this invention can be applied in a straight forward fashion for the simplified center adaptive algorithm that was recently disclosed.

Invention History

Published	[redacted]
Announced	
Disclosed	
Next Three Months	
Described	
Built	
Government Contract	
Related Disclosure	
Innovation Workshop	

Inventor Information

Inventors	David C Collins Hewlett-Packard Company Corvallis [redacted]

Witnesses

Witnesses	Richard Aufranc Hewlett-Packard Company Corvallis [redacted]

Classification

Recommended Classification	[redacted]
Keywords	
Recommended Merlin Entity	
Recommended Merlin Loc	
Recommended Merlin Responsible_attorney	

Administrative Record

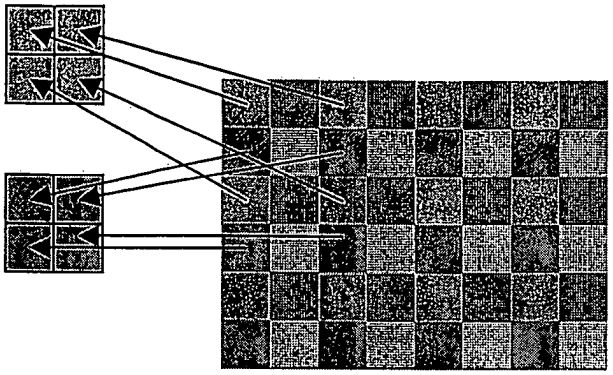
Date/Time Submitted	[redacted]
PD Number	200400519
Date PD Number Assigned	[redacted]

Filing Decisions

[redacted]

Adaptive Kernel With History

The following explanation is assuming 4 position wobulation. Thus, four low resolution subframes must be generated subframes – one for each image position. All of the subframes are processed together at the same time, and the subframes are intertwined. Thus, every four pixel will correspond to a different subframe. The following diagram illustrates the idea.



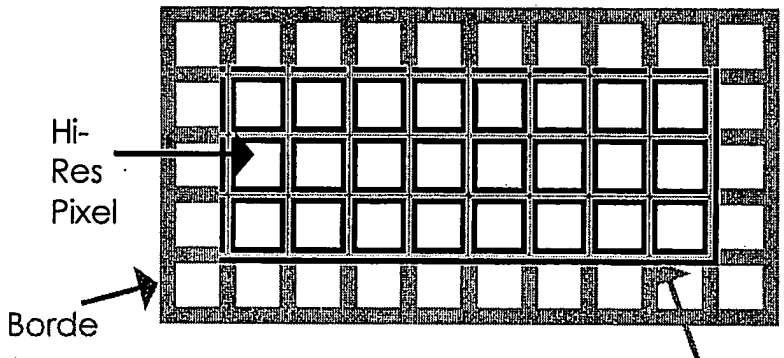
To compute the adaptive algorithm, subframes are computed, a simulated image (the four subframes merged together) is computed, an error image is computed. The error is averaged, and then feedback into the subframes. This process is repeated iteratively, and within a few iterations, this method converges to the solution. The standard adaptive algorithm is briefly defined below:

Simulation Kernel (K_s)

$$\begin{matrix} \frac{1}{4} & \frac{1}{4} & 0 \\ \frac{1}{4} & \frac{1}{4} & 0 \\ 0 & 0 & 0 \end{matrix}$$

Error Kernel (K_e)

$$\begin{matrix} 0 & 0 & 0 \\ 0 & \frac{1}{4} & \frac{1}{4} \\ 0 & \frac{1}{4} & \frac{1}{4} \end{matrix}$$



Iterative Algorithm

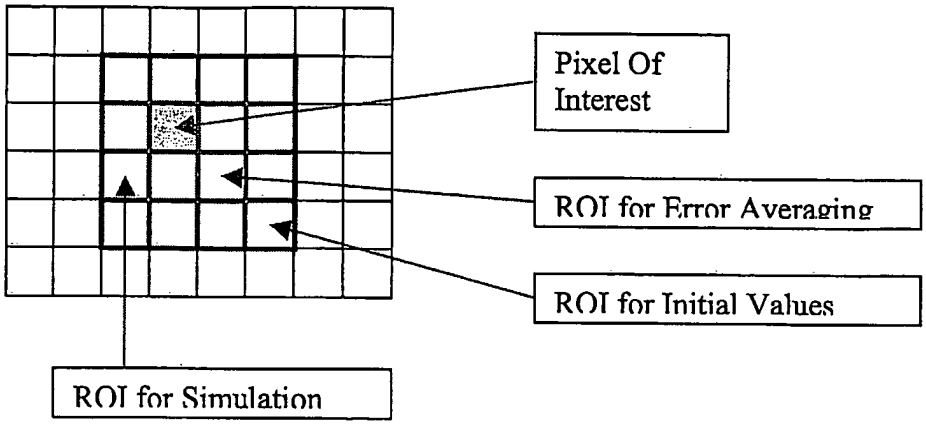
Simulation = K_s * Subframes

Error = Image – Simulation

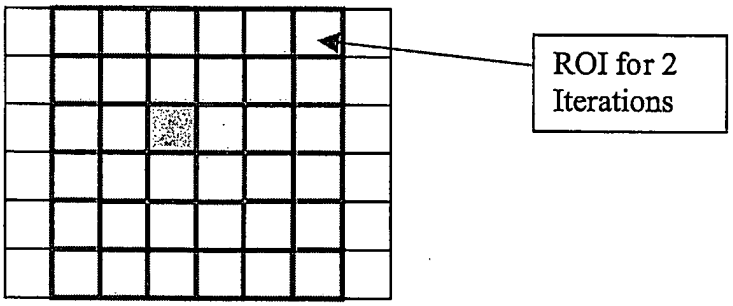
$Error_{avg}$ = K_e * Error

Subframes = Subframes + α x $Error_{avg}$

In order to calculate the subframe value for the a single pixel a 4x4 ROI is required for the one iteration. The diagram below illustrates the required pixel values.

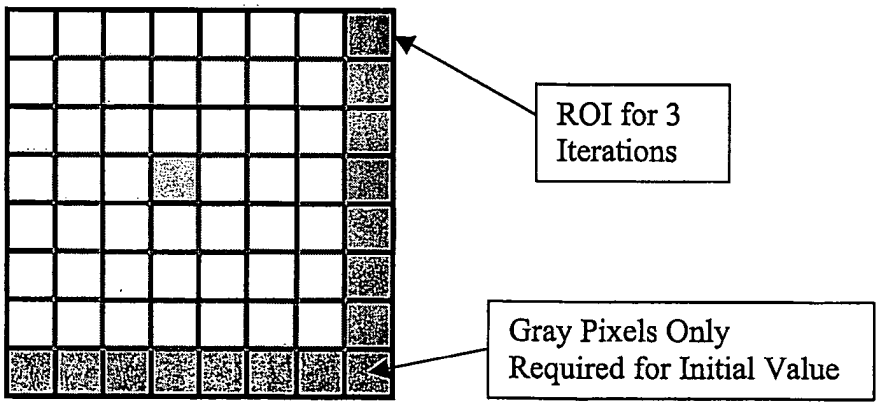


For two iterations, a 6x6 ROI is required.



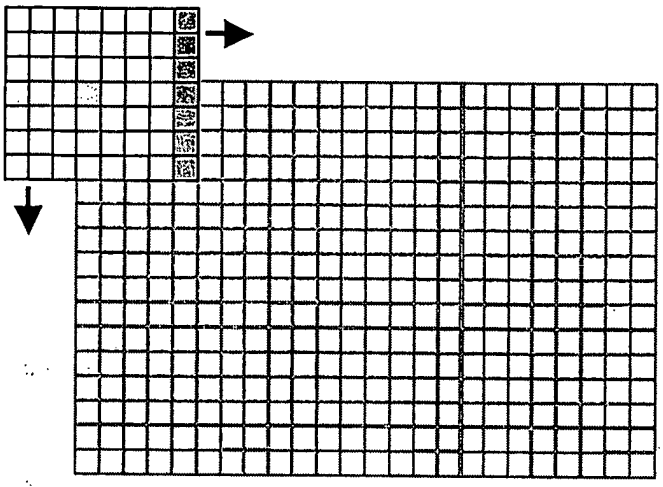
For 3 iterations an ROI of 8x8 is needed, and in general for n iterations an ROI of (2n+2)x(2n+2) is required.

Consider 3 iterations of the adaptive algorithm. To compute the optimal adaptive algorithm, an 8x8 ROI is required.

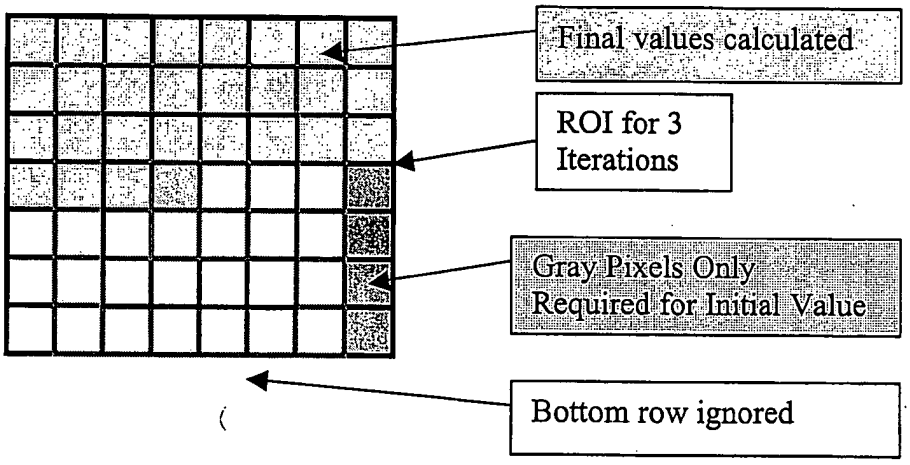


The bottom row of the ROI is only required to generate the initial guess for the pixel values that are at least 2 pixels away from the primary pixel of interest. There is very little impact in eliminating the last row from the ROI. This just implies that for some of the pixels a simplified calculation will have to be used for the initial subframe value.

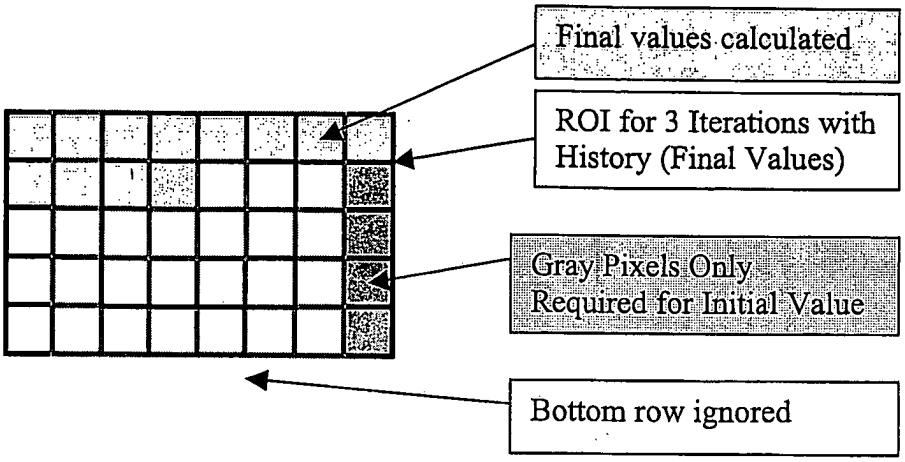
To generate the subframe values, the region of interest is positioned such that the pixel of interest is located over each pixel location. Typically, the ROI starts in the upper left corner, and the image is processed in a raster format. Thus, the first row of subframe values are calculated, followed by the second, and then the third row of data. The following image illustrates how the ROI is moved across the image and the subframe values are generated.



Since the image processing is typically done in a raster pattern. Many of the final subframe values will already have their final values computed. The diagram below illustrates the pixel locations with final values.



Now if we look at the calculations we can see that instead of using three pixel rows of image data above the pixel of interest, we can substitute the final calculated values instead. Thus, we can compute the 3-pass adaptive algorithm by using 1 row of the previously calculated subframe values along with 4 rows of the original image. This results in the following ROI:



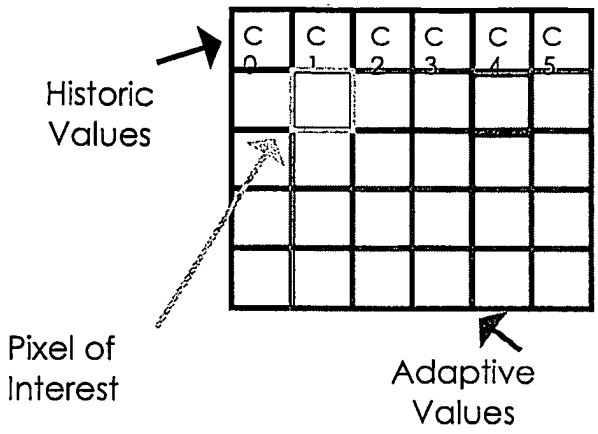
This same approach can be used for a variety of iterative or adaptive algorithms. Essentially two main simplifications have been done. First, instead of using a number of image rows above the pixel of interest, only one row is used, and this row contains the calculated subframe values and not the original image values. The second simplification comes from truncating the kernel in heighth, but not in width. It should also be obvious that these techniques can be applied to achieve more than 3 iterations. Three iterations was used for the example because it highlights the novelties of the invention, and three is about the right number of iterations to achieve almost all of the benefits of the iterative algorithm.

The benefits of this algorithm are best appreciated by an ASIC implementation. With this method the ASIC could be designed to include enough onboard memory to store the original image rows and one row of history (calculated subframe values). The image would be processed as it enters the ASIC. Only the final subframe values would need to be stored in external memory, and then read out at the proper time. Thus the memory bandwidth only has to support the writing and reading of a full frame of data. Also, as the kernel grows in height, more memory would be required on the ASIC. This explains why the goal was to reduce the number of rows needed by the ROI.

In summary, the 3-pass adaptive kernel with history can be implemented by a relatively simply algorithm. The following steps are performed once per pixel location.

Algorithm Steps

1 Calculate Adaptive C_4 (Initial Guess)
2 Calculate Sim C_4 (Convolve with Ks)
3 Calculate Error C_4 (Convolve with Ke)
4 Calculate Sim C_3
5 Calculate Error C_3
6 Calculate Adaptive C_3 ($x = x + \alpha$ Error)
7 Calculate Sim C_2
8 Calculate Error C_2
9 Calculate Adaptive C_2
10 Calculate Sim C_1
11 Calculate Error C_1



And for the truly inspired, the 3 pass adaptive algorithm can be implement with the following C++ code. The same approach has also been applied to the simplified center adaptive algorithm:

```
unsigned char AdaptiveStandardKernel::Calculate
(       unsigned char final0,
        unsigned char image1,
        unsigned char image2,
        unsigned char image3,
        unsigned char image4
)
{
        int temp;
        int x,y;        // temporary values to explicitly reduce the number of calculations

        shiftValues();

        final0_5M = final0;
        image1_5M = image1;
        image2_5M = image2;
        image3_5M = image3;
        image4_5M = image4;

        // calculate guess for column 4 -> average of 4 image pixels
        x         = image1_4M+image1_5M;
        y         = image2_4M+image2_5M;
        guess1_4M = (x+y)>>2;
        x         = image3_4M+image3_5M;
        guess2_4M = (x+y)>>2;
        y         = image4_4M+image4_5M;
        guess3_4M = (x+y)>>2;
        guess4_4M = y>>1;

        // compute sim column 4
        x          = final0_3M+final0_4M;
        y          = guess1_3M+guess1_4M;
        int sim1_4 = x+y;
        x          = guess2_3M+guess2_4M;
        int sim2_4 = x+y;
```

```
y          = guess3_3M+guess3_4M;
int sim3_4 = x+y;
x          = guess4_3M+guess4_4M;
int sim4_4 = x+y;

int err1_4  = (image1_4M<<2) - sim1_4;       // column 4
int err2_4  = (image2_4M<<2) - sim2_4;
int err3_4  = (image3_4M<<2) - sim3_4;
int err4_4  = (image4_4M<<2) - sim4_4;

// compute sim column 3
x          = final0_2M+final0_3M;
y          = guess1_2M+guess1_3M;
int sim1_3 = x+y; // column 3
x          = guess2_2M+guess2_3M;
int sim2_3 = x+y;
y          = guess3_2M+guess3_3M;
int sim3_3 = x+y;
x          = guess4_2M+guess4_3M;
int sim4_3 = x+y;

int err1_3  = (image1_3M<<2) - sim1_3;       // column 3
int err2_3  = (image2_3M<<2) - sim2_3;
int err3_3  = (image3_3M<<2) - sim3_3;
int err4_3  = (image4_3M<<2) - sim4_3;

// compute guess column 3
// divide by 4 for average error, 4 for simulation, & 4 for numerator
x     = err1_3+err1_4;
y     = err2_3+err2_4;
temp  = x+y;                                 // guess 1_3
temp  = (temp * alpha1M) >> 6;
temp  = temp + guess1_3M;
guess1_3M = max(0,min(temp,255));            // clip value

x     = err3_3+err3_4;
temp  = x+y;                                 // guess 2_3
temp  = (temp * alpha1M) >> 6;
temp  = temp + guess2_3M;
guess2_3M = max(0,min(temp,255));            // clip value

y     = err4_3+err4_4;
temp  = x+y;                                 // guess 3_3
temp  = (temp * alpha1M) >> 6;
temp  = temp + guess3_3M;
guess3_3M = max(0,min(temp,255));            // clip value

temp  = y;                                   // guess 4_3
temp  = (temp * alpha1M) >> 5;               // by 5 since x is not available
temp  = temp + guess4_3M;
guess4_3M = max(0,min(temp,255));            // clip value

x          = final0_1M+final0_2M;
y          = guess1_1M+guess1_2M;
int sim1_2 = x+y; // column 2
x          = guess2_1M+guess2_2M;
int sim2_2 = x+y;
y          = guess3_1M+guess3_2M;
int sim3_2 = x+y;
x          = guess4_1M+guess4_2M;
int sim4_2 = x+y;

int err1_2  = (image1_2M<<2) - sim1_2;       // column 2
int err2_2  = (image2_2M<<2) - sim2_2;
int err3_2  = (image3_2M<<2) - sim3_2;
int err4_2  = (image4_2M<<2) - sim4_2;

x     = err1_2+err1_3;
y     = err2_2+err2_3;
temp  = x+y;                                 // guess 1_2
temp  = (temp * alpha2M) >> 6;
```

```
temp  = temp + guess1_2M;
guess1_2M = max(0,min(temp,255));      // clip value

x     = err3_2+err3_3;
temp  = x+y;                           // guess 2_2
temp  = (temp * alpha2M) >> 6;
temp  = temp + guess2_2M;
guess2_2M = max(0,min(temp,255));      // clip value

y     = err4_2+err4_3;
temp  = x+y;                           // guess 3_2
temp  = (temp * alpha2M)>>6;
temp  = temp + guess3_2M;
guess3_2M = max(0,min(temp,255));      // clip value

temp  = y;                             // guess 4_2
temp  = (temp * alpha2M)>>5;
temp  = temp + guess4_2M;
guess4_2M = max(0,min(temp,255));      // clip value

x          = final0_0M+final0_1M;
y          = guess1_0M+guess1_1M;
int sim1_1 = x+y; // column 1
x          = guess2_0M+guess2_1M;
int sim2_1 = x+y;
y          = guess3_0M+guess3_1M;
int sim3_1 = x+y;
x          = guess4_0M+guess4_1M;
int sim4_1 = x+y;

int err1_1  = (image1_1M<<2) - sim1_1;       // column 1
int err2_1  = (image2_1M<<2) - sim2_1;
int err3_1  = (image3_1M<<2) - sim3_1;
int err4_1  = (image4_1M<<2) - sim4_1;

x     = err1_1+err1_2;
y     = err2_1+err2_2;
temp  = x+y;                           // guess 1_1
temp  = (temp * alpha3M)>>6;
temp  = temp + guess1_1M;
guess1_1M = max(0,min(temp,255));      // clip value

x     = err3_1+err3_2;
temp  = x+y;                           // guess 2_1
temp  = (temp * alpha3M)>>6;
temp  = temp + guess2_1M;
guess2_1M = max(0,min(temp,255));      // clip value

y     = err4_1+err4_2;
temp  = x+y;                           // guess 3_1
temp  = (temp * alpha3M)>>6;
temp  = temp + guess3_1M;
guess3_1M = max(0,min(temp,255));      // clip value

temp  = y;                             // guess 4_1
temp  = (temp * alpha3M)>>5;
temp  = temp + guess4_1M;
guess4_1M = max(0,min(temp,255));      // clip value

return guess1_0M;
}
```